Claims

[c1] An improved initialization method for a communication system comprising the steps of:
estimating a timing offset utilizing an entire received DMT frame; and
estimating a channel impulse response utilizing at least one pilot tone, wherein the received DMT frame further comprises the at least one pilot tone.

[c2] The method of claim 1, wherein the steps of estimating a timing offset and estimating a channel impulse response are performed substantially simultaneously.

[c3] The method of claim 1, wherein the received DMT frame comprises a plurality of DMT frames.

[c4] The method of claim 1, wherein the at least one pilot tone further comprises a plurality of pilot tones.

[c5] The method of claim 1, wherein the step of estimating timing offset information further comprises the steps of:
transmitting a plurality of DMT frames of length N+LP, where N is equal to the number of samples comprising the DMT symbol and LP is equal to the number of samples comprising a cyclic prefix;
receiving the plurality of DMT frames at a receiver;
performing interpolation on the received DMT frames; and
estimating an integer timing offset and a fractional timing offset from the DMT frames utilizing non-data aided maximum likelihood correlation with a pre-stored frame of length N+LP.

[c6] The method of claim 5, further comprising the step of correcting for the integer timing offset in the time-domain.

[c7] The method of claim 5, further comprising the step of correcting for the fractional timing offset in the frequency-domain.

[c8] The method of claim 1, wherein the step of estimating the channel impulse response further comprises the steps of:

transmitting a plurality of DMT frames comprising a plurality of known pilot tones;
receiving the DMT frames coincident with modem synchronization; and
estimating the channel impulse response utilizing MMSE criterion through the pilot tones.

[c9] The method of claim 8, further comprising synthesizing a 1-tap frequency domain equalizer based on the estimation of the channel impulse response.

[c10] The method of claim 9, wherein the channel impulse response is padded with zeroes to accommodate for circular convolution prior to synthesizing the 1-tap frequency domain equalizer.

[c11] The method of claim 8, wherein the plurality of pilot tones further comprises pilot tones modulated with a known symbol.

[c12] An improved method of estimating a timing offset utilizing an entire received DMT frame.

[c13] The method of claim 12, wherein the received DMT frame comprises a plurality of DMT frames.

[c14] The method of claim 12, further comprising the steps of:
transmitting a plurality of DMT frames of length N+LP, where N is equal to the number of samples comprising the DMT symbol and LP is equal to the number of samples comprising a cyclic prefix;
receiving the plurality of DMT frames at a receiver;
performing interpolation on the received DMT frames; and
estimating an integer timing offset and a fractional timing offset from the DMT frames utilizing non-data aided maximum likelihood correlation with a pre-stored frame of length N+LP.

[c15] The method of claim 14, further comprising correcting for the symbol timing offset in the time-domain responsive to the integer timing offset.

[c16] The method of claim 14, further comprising correcting for the sample timing offset in the frequency-domain responsive to the fractional timing offset.

[c17] An improved method of estimating a channel impulse response utilizing at least one pilot tone, wherein a received DMT frame further comprises the at least one pilot tone and the DMT frame is received during modem synchronization.

[c18] The method of claim 17, wherein the received DMT frame comprises a plurality of DMT frames.

[c19] The method of claim 17, wherein the at least one pilot tone further comprises a plurality of pilot tones.

[c20] The method of claim 17, further comprises estimating the channel impulse response utilizing Minimum Mean Square Error criterion for the known pilot tones.

[c21] The method of claim 20, further comprising synthesizing a 1-tap frequency domain equalizer based on the estimation of the channel impulse response.

[c22] The method of claim 21, wherein the channel impulse response is padded with zeroes to accommodate for circular convolution prior to synthesizing the 1-tap frequency domain equalizer.

[c23] The method of claim 20, wherein the plurality of pilot tones further comprise pilot tones modulated with a known symbol.

[c24] An improved initialization method for modem communication comprising the steps of:
transmitting a plurality of DMT frames of length N+LP, where N is equal to the number of samples comprising the DMT symbol and LP is equal to the number of samples comprising a cyclic prefix
transmitting a plurality of pilot tones within the plurality of DMT frames;
receiving the plurality of DMT frames at the receiver;
extracting timing offset information from the DMT frames through correlation with a pre-stored DMT frame, wherein correlation is performed using the entire DMT frame of N+LP samples;
performing interpolation on the received DMT frames resulting in an integer timing offset and a fractional timing offset; and

estimating the channel impulse response from the plurality of pilot tones within the received DMT frames.

[c25] The method of claim 24, further comprising:
correcting for a symbol timing offset in the time-domain responsive to the integer timing offset; and
correcting for a sample timing offset in the frequency-domain responsive to the fractional timing offset.

[c26] The method of claim 24, further comprises synthesizing a 1-tap frequency domain equalizer based on the estimation of the channel impulse response.

[c27] The method of claim 26, wherein the channel impulse response is padded with zeroes to accommodate for circular convolution prior to synthesizing the 1-tap frequency domain equalizer.

[c28] The method of claim 24, wherein the plurality of pilot tones further comprise pilot tones modulated with a known symbol.

[c29]
An improved initialization method for modem communication comprising the steps of:
transmitting a plurality of DMT frames of length N+LP, where N is equal to the number of samples comprising the DMT symbol and LP is equal to the number of samples comprising a cyclic prefix;
transmitting a plurality of known symbols over L known pilot tones within the plurality of DMT frames;
receiving the plurality of DMT frames at the receiver;
performing interpolation on the received DMT frames;
estimating an integer timing offset and a fractional timing offset from the DMT frames through correlation with a pre-stored DMT frame, wherein correlation is performed using the entire DMT frame of N+LP samples;
correcting for a symbol timing offset in the time-domain responsive to the integer timing offset;
correcting for a sample timing offset in the frequency-domain responsive to the fractional timing offset;

estimating the channel impulse response utilizing the L pilot tones within the received DMT frames;
padding the channel impulse response with (N-L) zeroes; and
synthesizing a 1-tap frequency domain equalizer based on the channel impulse response.

[c30] An improved system for modem communication comprising:
a timing offset estimator adapted to estimate a timing offset utilizing an entire received DMT frame; and
a channel impulse response estimator adapted to estimate a channel impulse response utilizing at least one pilot tone, wherein the received DMT frame further comprises the at least one pilot tone.

[c31] The system of claim 30, wherein the timing offset estimator and the channel impulse response estimator are adapted to operate substantially simultaneously.

[c32] The system of claim 30, wherein the received DMT frame comprises a plurality of DMT frames.

[c33] The system of claim 30, wherein the at least one pilot tone further comprises a plurality of pilot tones.

[c34] The system of claim 30, wherein the timing offset estimator further comprises:
a transmitter adapted to transmit a plurality of DMT frames of length N+LP, where N is equal to the number of samples comprising the DMT symbol and LP is equal to the number of samples comprising a cyclic prefix;
a receiver adapted to receive the plurality of DMT frames;
an interpolator adapted to perform interpolation on the received DMT frames; and
a correlator adapted to estimate an integer timing offset and a fractional timing offset from the DMT frames utilizing non-data aided maximum likelihood correlation with a pre-stored frame of length N+LP.

[c35] The system of claim 34, further comprising a symbol clock correction circuit adapted to correct a symbol timing offset in the time-domain responsive to the

integer timing offset.

[c36] The system of claim 34, further comprising a rotor-delay correction circuit adapted to correct a sample timing offset in the frequency-domain responsive to the fractional timing offset.

[c37] The system of claim 30, wherein the channel impulse response estimator estimates the channel response utilizing a Minimum Mean Square Error criterion of the known pilot tones.

[c38] The system of claim 37, further comprising a synthesizer adapted to synthesize a 1-tap frequency domain equalizer based on the estimation of the channel impulse response.

[c39] The system of claim 38, wherein the channel impulse response is padded with zeroes to accommodate for circular convolution prior to synthesizing the 1-tap frequency domain equalizer.

[c40] The method of claim 37, wherein the plurality of pilot tones further comprise pilot tones modulated with a known QAM symbol.

[c41] An improved system for estimating a timing offset utilizing an entire received DMT frame.

[c42] The system of claim 41, wherein the received DMT frame comprises a plurality of DMT frames.

[c43] The system of claim 41, wherein the timing offset estimator further comprises:
a transmitter adapted to transmit a plurality of DMT frames of length N+LP, where N is equal to the number of samples comprising the DMT symbol and LP is equal to the number of samples comprising a cyclic prefix;
a receiver adapted to receive the plurality of DMT frames;
an interpolator adapted to perform interpolation on the received DMT frames; and
a correlator adapted to estimate an integer timing offset and a fractional timing offset from the DMT frames utilizing non-data aided maximum likelihood correlation with a pre-stored frame of length N+LP.

[c44] The system of claim 43, further comprising correcting a symbol clock correction circuit adapted to correct a symbol timing offset in the time-domain responsive to the integer timing offset.

[c45] The system of claim 43, further comprising a rotor-delay correction circuit adapted to correct a sample timing offset in the frequency-domain responsive to the fractional timing offset.

[c46] An improved system for estimating a channel impulse response utilizing at least one pilot tone, wherein a received DMT frame further comprises the at least one pilot tone and the DMT frame is received during modem synchronization.

[c47] The system of claim 46, wherein the received DMT frame comprises a plurality of DMT frames.

[c48] The system of claim of claim 46, wherein the at least one pilot tone further comprises a plurality of pilot tones.

[c49] The system of claim 46, wherein the channel impulse response estimator estimates the channel response utilizing a Minimum Mean Square Error criterion of the known pilot tones.

[c50] The system of claim 49, further comprising a synthesizer adapted to synthesize a 1-tap frequency domain equalizer based on the estimation of the channel impulse response.

[c51] The system of claim 50, wherein the channel impulse response is padded with zeroes to accommodate for circular convolution prior to synthesizing the 1-tap frequency domain equalizer.

[c52] The method of claim 46, wherein the plurality of pilot tones further comprise pilot tones modulated with a known symbol.

[c53] An improved system for modem communication comprising the steps of:
a transmitter adapted to transmit a plurality of DMT frames of length N+LP, where N is equal to the number of samples comprising the DMT symbol and LP is equal to the number of samples comprising a cyclic prefix;

the transmitter adapted to transmit a plurality of pilot tones within the plurality of DMT frames;
a receiver adapted to receive the plurality of DMT;
a timing offset estimator adapted to estimate a timing offset from the DMT frames through correlation with a pre-stored DMT frame, wherein correlation is performed using the entire DMT frame of N+LP samples;
an interpolator adapted to interpolate the received DMT frames resulting in an integer timing offset and a fractional timing offset; and
a channel impulse estimator adapted to estimate the channel impulse response from the plurality of pilot tones within the received DMT frames.

[c54] The system of claim 53, further comprising:
a symbol clock correction circuit adapted to correct a symbol timing offset in the time-domain responsive to the integer timing offset; and
a rotor-delay correction circuit adapted to correct a sample timing offset in the frequency-domain responsive to the fractional timing offset.

[c55] The system of claim 53, further comprising a synthesizer adapted to synthesize a 1-tap frequency domain equalizer based on the estimation of the channel impulse response.

[c56] The system of claim 55, wherein the channel impulse response is padded with zeroes to accommodate for circular convolution prior to synthesizing the 1-tap frequency domain equalizer.

[c57] The system of claim 53, wherein the plurality of pilot tones further comprise pilot tones modulated with a known symbol.

[c58]
An improved system for modem communication comprising:
a transmitter adapted to transmit a plurality of DMT frames of length N+LP, where N is equal to the number of samples comprising the DMT symbol and LP is equal to the number of samples comprising a cyclic prefix
the transmitter transmitting a plurality of known symbols over L known pilot tones within the plurality of DMT frames;
a receiver adapted to receive the plurality of DMT frames;

an interpolator adapted to interpolated the received DMT frames;

a timing offset estimator adapted to estimate an integer timing offset and a fractional timing offset from the DMT frames through correlation with a pre-stored DMT frame, wherein correlation is performed using the entire DMT frame of N+LP samples;

a symbol clock corrector circuit adapted to correct a symbol timing offset in the time-domain responsive to the integer timing offset;

a delay-rotor circuit adapted to correct a sample timing offset in the frequency-domain responsive to the fractional timing offset;

a channel impulse response estimator adapted to estimate the channel impulse response utilizing the L pilot tones within the received DMT frames;

a circular convolution circuit adapted to pad the channel impulse response with (N-L) zeroes; and

a synthesizer adapted to synthesize a 1-tap frequency domain based on the channel impulse response.